

**Unit Title:**

High School: Total Solar Eclipse Phenomena

**Standard**

[http://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South\\_Carolina\\_Academic\\_Standards\\_and\\_Performance\\_Indicators\\_for\\_Science\\_2014.pdf](http://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf)

*The solar eclipse phenomena finds direct correlation to high school Earth Science standards. However, other high school teachers are encouraged to use these resources below to teach their students about the unusual phenomena that is occurring across our state, a total solar eclipse. It is important that all students, regardless of grade or course, be prepared for this amazing science phenomena preceding the event on August 21, 2017. The information below begins with the overall learning needed for all high school students and then continues with deeper extension activities designed to enhance interest in, understanding of, and appreciation for this once in a lifetime event.*

**Earth Science:**

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe.

**Biology:**

Standard H.B.6: The student will demonstrate an understanding that ecosystems are complex, interactive systems that include both biological communities and physical components of the environment.

**Chemistry:**

Standard H.C.2: The student will demonstrate an understanding of atomic structure and nuclear processes.

Standard H.C.4: The student will demonstrate an understanding of the structure and behavior of the different states of matter.

**Physics:**

Standard: H.P.2: The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.

**New Academic Vocabulary**

Some students may need extra support with the following academic vocabulary in order to understand what they are being asked to understand and do. Teaching these terms in an instructional context is recommended rather than teaching the words in isolation. A great time to deliver explicit instruction for the terms would be during the modeling process. Ultimately, the student should be able to use the academic vocabulary in conversation with peers and teachers. These terms are pulled from the essential knowledge portion of the Support Doc 2.0 (<http://ed.sc.gov/instruction/standards-learning/science/support-documents-and-resources/>) and further inquiry into the terms can be found there.

Annular eclipse

Altitude

Azimuth

Corona

Eccentricity

Insolation

Lunar eclipse	New Moon	Path of totality	Penumbra	Total solar eclipse	Umbra
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Prior Knowledge
<ul style="list-style-type: none"> <li>8.E.4 Earth's solar system</li> <li>8.E.4 Gravity</li> <li>8.E.4 Effects of motion within the Earth- Moon-Sun system</li> </ul>
Subsequent Knowledge
<ul style="list-style-type: none"> <li>H.P.2D Universal Law of Gravitation</li> </ul>

Teacher Background Information on Total Solar Eclipse
<ul style="list-style-type: none"> <li>General background information for teachers on solar eclipses. <a href="http://www.mreclipse.com/Special/SEprimer.html">http://www.mreclipse.com/Special/SEprimer.html</a></li> <li>An Observer's Guide to Viewing the All-American Total Solar Eclipse provided by NSTA. <a href="http://static.nsta.org/extras/solarscience/SolarScienceInsert.pdf">http://static.nsta.org/extras/solarscience/SolarScienceInsert.pdf</a></li> <li>"Get Ready for the Great American Eclipse!: A once-in-a-lifetime event provides an opportunity to increase science literacy": This article published in the January 2017 edition of <i>Science and Children</i> offers insight into the August 21, 2017 eclipse and outlines the importance of fostering scientific literacy when teaching about the eclipse. <a href="http://static.nsta.org/files/sc1705_60.pdf">http://static.nsta.org/files/sc1705_60.pdf</a></li> <li>A quick video that explains the three types of solar eclipses <a href="https://www.youtube.com/watch?v=is8OLhGgLAE">https://www.youtube.com/watch?v=is8OLhGgLAE</a></li> </ul>

Instructional Strategies/Lessons
Strategies and lessons that will enable students to understand the total eclipse phenomena.
<p><b>1. Eye Safety:</b></p> <p style="text-align: center;"><b>Essential Question: How can I safely watch the entire total solar eclipse?</b></p> <ul style="list-style-type: none"> <li>Eye safety information: All students should receive careful instruction in this area. Concerns for eye safety during a total solar eclipse provided by NASA can be found using this link. <a href="https://eclipse.gsfc.nasa.gov/SEhelp/safety.html">https://eclipse.gsfc.nasa.gov/SEhelp/safety.html</a></li> <li>This link contains information concerning the importance of eye safety, brands of viewers that are available for sale, and the standards they must meet. <a href="https://eclipse.aas.org/eye-safety/iso-certification">https://eclipse.aas.org/eye-safety/iso-certification</a></li> <li>NASA has created a video that teaches students how to make a viewer with binoculars and a tripod.</li> </ul>

<https://eclipse2017.nasa.gov/solar-viewing-projector>

- Make a sun funnel by building a solar viewing projector that fits right over the eyepiece of your telescope.

<https://eclipse2017.nasa.gov/make-sun-funnel>

- The following video explains how pinhole cameras work.

<https://www.youtube.com/watch?v=rHHTfGzaiuA>

- NASA's information concerning eye safety is outlined on this site.

<https://www.nasa.gov/content/eye-safety-during-a-total-solar-eclipse>

## 2. Exploration of a Total Solar Eclipse:

**A. Possible Introductory Activities Through Asking Questions and Defining Problems:** *Choose from the following bulleted items to elicit student thinking about total solar eclipses. Science begins with questions about phenomena, seeking to gather the evidence necessary to construct an explanation about the phenomena. Asking questions leads towards inquiry and drives science and engineering. It is an essential practice to developing scientific habits of mind. These questions are driven by curiosity, by the desire to understand a phenomenon, or by the need to solve a problem. In science, a question should always lead to an investigation to acquire the necessary evidence in an attempt to answer that question.*

### Essential Question: Why will there be darkness during the day on August 21, 2017?

- **Weather Satellite Video of a Total Solar Eclipse:** This is a time-lapse video recorded by the weather satellite Himawari-8 of a total solar eclipse passing over the Pacific Ocean. The teacher should not reveal any information about the source or content of the video. After viewing, have students pair-share about what they noticed and what they thought they witnessed. Have students develop hypotheses about the cause *and direction* of the shadow moving across the Pacific Ocean. Because the video is very short (five seconds), the teacher may need to replay it multiple times as the discussion progresses. At the Digital Typhoon: Total Solar Eclipse of March 9, 2016 website, find the "Animation" header and click on the "RGB" link below it to view the video. It can be downloaded from the website as well: <http://agora.ex.nii.ac.jp/digital-typhoon/solar-eclipse/20160309/>. An alternative site, but not as data-rich is [http://cimss.ssec.wisc.edu/goes/blog/wp-content/uploads/2016/03/1750x2750\\_AHIM08\\_B1\\_NHS\\_animated\\_2016068\\_233000\\_86\\_2016069\\_043000\\_86\\_X.mp4](http://cimss.ssec.wisc.edu/goes/blog/wp-content/uploads/2016/03/1750x2750_AHIM08_B1_NHS_animated_2016068_233000_86_2016069_043000_86_X.mp4).
- **Deep Space Climate Observatory (DSCOVR) Animation of the Moon Crossing the Face of the Earth:** After viewing the video above of a total solar eclipse and having students discuss the phenomenon and predict what might be causing it, present this animation of the moon crossing the face of the earth produced with images from the DSCOVR geostationary satellite. Elicit student ideas by asking the following questions: 1. What stands out to you about these images? 2. What questions come to mind while viewing these images? 3. What do you think is happening in this sequence of images? 4. How are these images related to the ones from the

weather satellite video? 5. What might be the relationship between the objects depicted in the images? Again, this should be student-driven discussions.

<https://www.nasa.gov/feature/goddard/from-a-million-miles-away-nasa-camera-shows-moon-crossing-face-of-earth>

- **Time-lapse video from Iceland and Time-lapse simulation of the August 21, 2017 total solar eclipse:** After viewing the weather satellite and DSCOVR videos, have students view videos of a total solar eclipse from the surface of the earth. Students should, by this time, have come to the conclusion that the phenomenon being observed in all videos and images is a total solar eclipse. Students observe a time-lapse video of a total solar eclipse from Iceland. Again, ask students the following questions: 1. What stands out to you about these images? 2. What questions come to mind while viewing these images? 3. What do you think is happening in this sequence of images? 4. How are these images related to the ones from the weather satellite and DSCOVR videos? 5. What might be the relationship between the objects depicted in the images?

Iceland video: <https://www.youtube.com/watch?v=ZAxlOS7za8I>

Aug 21, 2017 simulation: [https://www.youtube.com/watch?v=vzJqeyxye\\_E](https://www.youtube.com/watch?v=vzJqeyxye_E)

**Literary technique to support learning goal:** *Teachers may choose from the following literary techniques and bulleted options (texts, videos, or websites) below that will assist in creating the learning around asking questions about the total solar eclipse and transacting with text. These strategies can be used before, during, or after any guided content.*

1. **Say/Mean/Matter** (Burnett & McEwan-Adkins, 2013): *Students should be given a purpose for reading in the form of a question. With the students, read through the text, modeling your thinking as to what you highlighted for keywords that help answer the purpose question. Then verbally discuss your thinking to annotate in the margins your response to the text (opinion, questions, or pushback). Ask students to continue that process as they continue to read the text by highlighting key words or phrases within the text that answers the question and annotating their responses. Next, have students to draw a three column T-chart on paper. On the left side of the chart, write “Say”. In the middle of the chart, write “Mean”; and on the right side of the chart, write “Matter”.*

<b>Say</b>	<b>Mean</b>	<b>Matter</b>
<i>Quotes or paraphrasing directly from the text.</i>	<i>What does the “Say” mean to you in reference to answering the purpose question?</i>	<i>Why does the “Say” matter to the context of the topic in reference to answering the question?</i>

*Walk through the first few highlighted key words or phrases with the students to fill in the “Say” column. Then, lead the students in a discussion on what “Say” means and as a group decide what to put in the “Mean” column. Lastly, lead the students in a discussion on why the “Say” matters and decide as a group what to put in the “Matter” column. Let students continue the chart using the remaining portion of the text. This can be done in collaborative groups or independently. Once students have their Say/Mean/Matter charts completed, guide them in writing a response to the purpose question using the information from the Say/Mean/Matter chart.*

**2. Annotating for Aha Moments** (Beers and Probst, 2012): First, explain to students that their insight or sudden understanding reveals something important about what they have read. The teacher will ask the students to look for moments that make you think, “Oh, I hadn’t thought of that before,” or “I hadn’t realized this was possible.” Ask yourself, “Why might this realization be important?” Then, tell students that they should have a minimum of one Aha moment per finding. Lastly, ask students to create a four column T-chart on paper. With the students, read through the text modeling your thinking as to what you highlighted for Aha moments. Then verbally discuss your thinking to annotate in the margins your realizations from the Aha moment. Ask students to continue that process as they continue to read the text. As students complete the text, model completing the chart directly from your highlights and annotations. Monitor students as they work on their charts.

<b><i>What words told you this was going to be an Aha moment?</i></b>	<b><i>Pg.#</i></b>	<b><i>What realization came to your mind while reading the text?</i></b>	<b><i>Why is this realization important?</i></b>
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Choose from the following resources to support student engagement with the total solar eclipse and transaction with text.

**Literary/Informational texts:**

- Students read an excerpt from A Connecticut Yankee in King Arthur’s Court by Mark Twain.  
<https://www.nsta.org/publications/press/extras/files/solarscience/chapter4/AConnecticutYankeeInKingArthursCourtExcerpt.pdf>  
 Below are some discussion-based questions you may consider using during or after students read the excerpt:
  - Why was the king willing to give up so much to “spare the sun”?
  - Why did the eclipse bring “cold uncanny night breezes” to the region?
  - Explain how stars could be out around noon, and why we do not see them every day.
  - Why do you think the people were so afraid of the solar eclipse?
  - Why do you think the people seemed to have no understanding of what was happening?
- “Prisoners of the Sun” by Herge is a solar eclipse story. A synopsis can be read at the following site:  
<http://colorsofindia.com/eclipse/eclipstorytintin.htm>
- “The Eclipse” by James Fenimore Cooper is an autobiographical vignette written between 1833 and 1838. James Fenimore Cooper recounts his own experience witnessing a solar eclipse in Cooperstown on the morning of June 16, 1806. The author’s daughter found it among her father’s papers after his death and had it published. The short story can be downloaded for free at <https://americanliterature.com/author/james-fenimore-cooper/short-story/the-eclipse> .
- “Beyond a Shadow of a Doubt: the Science Behind Eclipses”: Students read and answer questions. This activity can be done as print version or online.  
[http://www.algebrablab.org/passage/passage.aspx?file=EarthSpace\\_Eclipses.xml](http://www.algebrablab.org/passage/passage.aspx?file=EarthSpace_Eclipses.xml)

- “An Observer's guide to the viewing the eclipse”: This guide from *The Science Teacher Magazine March 2017* covers all the information needed for teaching the eclipse.  
Download the information at [static.nsta.org/extras/solarscience/SolarScienceInsert.pdf](http://static.nsta.org/extras/solarscience/SolarScienceInsert.pdf).
- This is a resource for some mythologies pertaining to solar eclipses from National Geographic. There are several sources teachers may use to allow students to read about how different cultures viewed this phenomena through the ages.  
<http://news.nationalgeographic.com/news/2013/11/131101-solar-eclipse-myth-legend-space-science/>  
<http://www.kidseclipse.com/pages/a1b3c5d0.htm>  
<https://www.timeanddate.com/eclipse/solar-eclipse-myths.html>

#### Videos:

- *Earth-Sun-Moon Scale Model*: A senior scientists at Exploratorium explains the scale of the earth, sun, and moon system and how that is related to total solar eclipses. Give the video time to download (watch the bar below the video) to prevent buffering while showing. [https://www.youtube.com/watch?v=NNx\\_iiU2HA8](https://www.youtube.com/watch?v=NNx_iiU2HA8)
- *What is a Solar Eclipse?*: The celestial mechanics of a total solar eclipse are explained and demonstrated. Give the video time to download (watch the bar below the video) to prevent buffering while showing.  
<https://www.exploratorium.edu/eclipse/video/what-is-solar-eclipse>
- NASA EDGE: Eclipse 2017 Preview: This video is 29:31 long. [https://www.youtube.com/watch?v=vKAk\\_-zFWVI](https://www.youtube.com/watch?v=vKAk_-zFWVI)  
It is also available at <https://www.nasa.gov/nasa-edge/1005-solar-eclipse-2017-preview-show>.  
There is an entire script of the video at the second link teachers may find helpful.
- Located under Educational Videos, the resource Watch 2017 Eclipse PSA is a short public service announcement from the Fiske Planetarium which could spark interest in the August eclipse. <http://www.starnetlibraries.org/2017eclipse/eclipse-resource-center/>
- Located under Educational Videos, the resource *Watch 2017 Eclipse FAQs* is a six minute video covering frequently asked questions about a total solar eclipse from the Fiske Planetarium <http://www.starnetlibraries.org/2017eclipse/eclipse-resource-center/>
- Located under Education Videos, the resource *Watch 2017 Eclipse Overview* is a short NASA Goddard video that aids in visualizing the eclipse moving across the US. <http://www.starnetlibraries.org/2017eclipse/eclipse-resource-center/>


#### Websites:

- This site provides a simplified explanation of Lunar and Solar Eclipses from NASA.  
<http://spaceplace.nasa.gov/eclipses/en/>
- Promethean Planet (Class Flow): Set up a free account and search “Amanda Neumann.” Her material explains and shows what happens during a solar eclipse to help students visualize the process taking place.  
<https://classflow.com/classflow/#!/product/itemId=146f7b8431f648d7ad5c3dd6e8b905ee>
- Mr. Eclipse’s website has numerous resources teachers can use.  
<http://www.mreclipse.com/MrEclipse.html>
- Great American Eclipse is another site with numerous resources.

<https://www.greatamericaneclipse.com/>

**B. Total Solar Eclipse Exploration Through Modeling:** *Teachers may choose from the following bulleted options that will assist in creating the learning centered around modeling and the total solar eclipse. The Science and Engineering Practice of developing and using models is used to understand and represent the total solar eclipse phenomena, processes, and relationships. Models may serve as a way to answer scientific questions asked above by students. Below you will find multiple modeling options to choose from to engage your students in this SEP while learning about the total solar eclipse phenomena. Each student should have the opportunity to participate in at least one of these structured investigations to model a total solar eclipse.*

**NOTE:** Some activities included in the resources below require Adobe Flash Player. If you use Chrome as your default browser, Flash Player may be disabled. If you have an up-to-date version of Flash Player use the following steps to turn on Adobe Flash in Chrome:

1. Open Chrome.
2. At the top right, select More , then Settings.
3. At the bottom, select Show Advanced Settings.
4. Under Privacy, select Content Settings.
5. Scroll until you find Flash and choose "Ask first before allowing sites to run Flash."
6. At the bottom, select Done.
7. If you do not have Adobe Flash Player installed, it can be downloaded at [https://get.adobe.com/flashplayer/?no\\_redirect](https://get.adobe.com/flashplayer/?no_redirect).

### **Essential Question: How can I model what happens during a Total Solar Eclipse?**

- This whole class activity develops a model to observe what occurs during a solar eclipse. Materials required include a globe, Styrofoam ball, string or line, lamp or light source, and some type of hook.  
[http://www.eyeonthesky.org/lessonplans/11sun\\_eclipseclass.html](http://www.eyeonthesky.org/lessonplans/11sun_eclipseclass.html)
- Students will create their own solar eclipse. Materials required are a flashlight, an orange, a ball of clay  $\frac{1}{2}$  the size of the orange, and a ruler. <https://www.teachervision.com/activity/make-your-own-solar-eclipse>
- ***Big Sun, Small Moon:*** Why do the sun and moon look like they are the same size in the sky? Students will explore the size difference between the moon and sun and participate in an activity that will explain how the sun's light can be blocked by the moon. Materials required are a large coin (quarter) or a circle of the same size and a large round dinner plate or a circle of the same size. [http://lawrencehallofscience.org/static/diy\\_sun\\_science/downloads/diy\\_ss\\_bigsun\\_smallmoon.pdf](http://lawrencehallofscience.org/static/diy_sun_science/downloads/diy_ss_bigsun_smallmoon.pdf)
- ***Modeling Eclipses:*** Students will make observations and construct explanations to explain what happens during a solar eclipse. Materials required are Styrofoam balls and a lamp. There is an extension described in the activity that would require two hula hoops. <http://solar-center.stanford.edu/eclipse/model.html>
- This site provides a meaningful model of the total eclipse. A video is also available which helps with building the model.  
<https://nightsky.jpl.nasa.gov/docs/ModelMeaningfulEclipses2016.pdf>
- Students can use this physical model to demonstrate how an eclipse occurs.



[https://sunearthday.nasa.gov/2006/images/eclipsing\\_the\\_sun2.pdf](https://sunearthday.nasa.gov/2006/images/eclipsing_the_sun2.pdf)

- Modeling Eclipses: Using a small Styrofoam ball, a light bulb, and students' heads, students learn how eclipses work. <http://solar-center.stanford.edu/eclipse/model.htm>
- Students can look at a model of an eclipse using a 3D solar system computer program called Celestia that must be downloaded. Use Celestia to observe a space view of the eclipse. Download Celestia at <https://sourceforge.net/projects/celestia>.

**TEACHER BASIC DIRECTIONS and ORIENTATION for Celestia:**

1. Download Celestia at <http://www.shatters.net/celestia/> and open.
  2. Once Celestia opens, select Navigation tab at the top.
  3. Select Eclipse finder.
  4. Set button to solar eclipse and change "from" date to 20 August 2017 and the "to date" to 22 August 2017. Click "compute". Select the August 21, 2017 date. Then select 'set date and go to planet'. The eclipse path will become visible. See Step 5 for how to alter speed and direction of the eclipse. The recommendation is not to go faster than 1000X normal speed.
  5. The L key speeds up the animation, the K key slows down the animation, and the J key changes from forward to backward. If you right click while using your mouse, you can change the orientation of the earth. Additional control options can be found in the Help menu in Celestia controls.
  6. You can also download a simulation of this eclipse over Europe at <http://www.celestiamotherlode.net/catalog/scripts.php>. Scroll down the page for 'Solar Eclipse 1999'. Once it is downloaded and saved, it can be easily opened and viewed. In Celestia, select File/Open Scripts, select the script Solar Eclipse 1999 and it will run.
- Students can create a computer model of the total solar eclipse in Australia (November 14, 2012). This activity can be done on individual computers or shown interactively to a larger group. The directions are found at <http://eclipse.aaq.org.au/index.php/classroom-activities/tse-2012-activities?download=42:activity-07-tse-2012-simulation>. The Stellarium program must be downloaded and is available at <https://sourceforge.net/projects/stellarium/>. Once students have looked at the Australian eclipse, have them produce a simulation of the August 21, 2017 eclipse. They may need to be provided UTC times. If they have not already been exposed to that information, the teacher could give them EDT and have them convert to UTC. They will not need to change the landscape to ocean. Students can compare similarities and differences between the two eclipses. To escape the program use CTRL Q. Other directions needed to manipulate the program are found in the directions referenced in the simulation pdf.
  - Students model solar and lunar eclipses and draw explanations for both after modeling. Directions are available at the following website <https://starchild.gsfc.nasa.gov/docs/StarChild/teachers/moonglow.html>.

**C. Total Solar Eclipse Exploration Through Analyzing and Interpreting Data:** *Choose from the following bulleted items to elicit student thinking about total solar eclipses through analyzing and interpreting data. The Science and Engineering Practice of analyzing and interpreting data is used to understand what occurs during the total solar eclipse phenomena. Analysis and interpretation of data may serve as a way to answer scientific questions asked by students. Each student should have the opportunity to participate in the collection and analysis of data while participating in a structured investigation.*

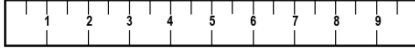


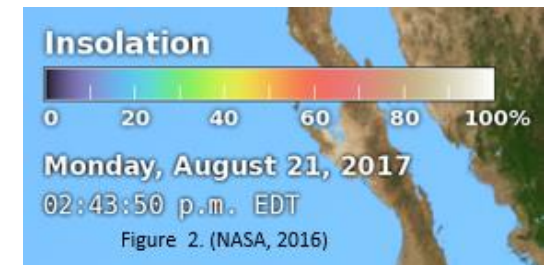
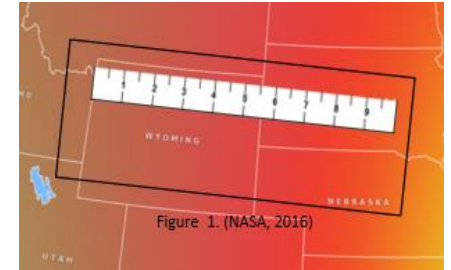
### Essential Question: What is the path and timing of the total solar eclipse?

- Students enter unique coordinates to determine specific details about the eclipse at a designated location, like their school. The website is <http://aa.usno.navy.mil/data/docs/Eclipse2017.php>. Data is entered in form B. At the bottom of the page, students can enter a query using the GNIS link to obtain needed latitude, longitude, and elevation for the specific location they choose. Students will learn about the altitude and azimuth, important angles used in astronomy. Interpreting data can involve comparing results of different searches or simply converting UDT to EDT.
- *Suntrek's Classroom Project*: This is a set of mathematics-based labs intended for high school students, using data from ESA/NASA's Solar, Heliospheric Observatory (SOHO), and NASA's Solar Dynamics Observatory (SDO) missions. It includes many Space Math problems originally developed by NASA's Sten Odenwald. This activity collection originated from Helen Mason and Miriam Chaplin at Cambridge University, England. Activity 6 has the data activity.  
<http://solar-center.stanford.edu/activities/Suntrek/>.
- Students can manipulate a model of the sun, earth, moon system, while interpreting and analyzing observations and data, to describe why eclipses are not monthly events. The interactive has explorations that can be used.  
[http://higher.ed.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::640::480::sites/dl/free/007299181x/220730/eclipse\\_interactive.swf::Eclipse%20Interactive](http://higher.ed.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::640::480::sites/dl/free/007299181x/220730/eclipse_interactive.swf::Eclipse%20Interactive)
- *Getting Ready for the All American Eclipse* is a series of lessons produced by the Astronomical Society of the Pacific. All lessons have application for this unit. For the purposes of analyzing and interpreting data, begin on page 8, third column. Use the driving question: "Why don't we see eclipses every month?". All of the materials needed are available through links on the last page of the document. It is important that students have created a model of the eclipse *prior* to completing this activity. This resource is available at <https://www.astrosociety.org/wp-content/uploads/2016/10/uitc93.pdf>.
- Students can watch the video *Tracing the 2017 Solar Eclipse* to learn how the data from various sources was analyzed and interpreted to produce the animations of the path of the eclipse across the United States.  
<https://www.nasa.gov/feature/goddard/2017/nasa-moon-data-provides-more-accurate-2017-eclipse-path>
- Students will analyze past and future solar and lunar eclipse data to determine a pattern in total solar eclipses occurrences. After creating their pattern (hypothesis), the students will research information concerning the appearances of solar eclipses and why they occur. They will use this research to determine if they met their hypothesis. <https://eclipse.gsfc.nasa.gov/SEpath/SEpath.html>
- Insolation during the 2017 Eclipse This visualization from NASA tracks the changing insolation along the path of the August 2017 eclipse across the US. Depending upon the math experiences of student, some may not understand the sine of an angle (in this case solar altitude). The essential knowledge here is that as the sun gets higher in the sky, the amount of heating increases as well.  
<https://svs.gsfc.nasa.gov/4466>
  - Applicable vocabulary:  
insolation- the amount of solar energy reaching earth's surface

solar altitude- the sun's position above the horizon

obscuration-refers to how much of the sun is blocked by the moon during the eclipse

- Possible extensions based on computational and mathematical thinking using this map could include:
  - Have students calculate the distance in kilometers for the northern border of Wyoming. This state was chosen due to the magnitude of the distance which is 342 mi. Using the conversion factor of 1.61 km, the product will be 550.62 km, which can be tweaked to 550 km for the sake of convenience.
    1. Use the map on the link above.
    2. Allow the video to play until the umbra is in the desired position, then pause.
    3. Open Snip Tool or another screenshot utility tool to make a copy of the map.
    4. Paste it on a WORD document or onto a projection board like SmartBoard.
    5. Copy this ruler. 
    6. Insert a textbox on the pasted map that has been formatted with no fill color, and paste the ruler into it. (This will allow for the ruler to be manipulated in position and size.)
    7. Position the ruler over the northern border of Wyoming, and size the ruler so that 5.5 cm equals the northern border of the state. Clicking on the ruler inside of the textbox allows for sizing so the scale is 1cm = 100 km as shown in Figure 1.
    8. Keep the ruler at this scale for the remainder of the activity.
    9. Have the students determine an approximate diameter of the umbra using the scaled ruler.
    10. Without looking it up on the Internet, have the students determine the approximate length of the path of totality from the start of the eclipse on the west coast to the end of the eclipse on the east coast. The distance will be approximately 3,027 mi or 4,873 km. Students may question the size of the ruler and the ability to measure across the US. This is an exercise in problem solving so allow the students to find their own solution making this measurement.
      - Possible solutions could be marking the coast of Oregon and South Carolina with tick marks on a piece of paper and making a scale of the ruler to determine the distance.
      - Based on the time the eclipse starts on the west coast, students will determine the times for given percentages of insolation. (For example: "At what time will insolation drop to 50% in Columbia, SC?")
    11. Students will use the distance calculated in the activity above and the time counter from the map to



determine the velocity of the umbra across the US. (Figure 2)

- Students will use mathematical and computational thinking to understand the terms altitude and azimuth. General information about the terms, along with diagrams can be found at [http://www.astro.cornell.edu/academics/courses/astro201/alt\\_az.htm](http://www.astro.cornell.edu/academics/courses/astro201/alt_az.htm) and <http://astro.unl.edu/naap/motion2/observer.html>. Using the Azimuth/Altitude Demonstrator at <http://astro.unl.edu/classaction/animations/coordsmotion/altazimuth.html> will allow students to explore these terms by manipulating the star and seeing the effects of movement on both measurements. The same exploration could be done with an entire class using an interactive whiteboard. Using data from the US Navy ([http://aa.usno.navy.mil/solareclipse?eclipse=22017&place=USC&lon\\_sign=-1&lon\\_deg=081&lon\\_min=01&lon\\_sec=35&lat\\_sign=1&lat\\_deg=33&lat\\_min=59&lat\\_sec=57&height=33](http://aa.usno.navy.mil/solareclipse?eclipse=22017&place=USC&lon_sign=-1&lon_deg=081&lon_min=01&lon_sec=35&lat_sign=1&lat_deg=33&lat_min=59&lat_sec=57&height=33)) shown below, students can move the star across the sky to match the measurements, to visualize the movement of the sun on the day of the eclipse.

### Solar Eclipse Computer

U.S. Naval Observatory  
Astronomical Applications Department

Solar Eclipse of 2017 Aug. 21

Sun in Total Eclipse at this Location

USC (Longitude W81° 1' 35.0", Latitude N33° 59' 57.0", Height 33m)

August 21, 2017		Universal Time					Delta T: 69.4s
Phenomenon	Day	Time	Altitude	Azimuth	Position Angle	Vertex Angle	
Eclipse Begins	21	17:13:08.5	67.6	171.0	294.1	301.9	
Totality Begins	21	18:41:50.0	62.1	222.0	99.0	64.6	
Maximum Eclipse	21	18:43:05.0	61.9	222.5			
Totality Ends	21	18:44:21.6	61.7	223.1	311.1	275.9	
Eclipse Ends	21	20:06:19.3	47.6	248.2	115.2	63.4	
Duration		2h 53m 10.7s					
Duration of Totality		2m 31.7s					

**3. Possible Culminating Activities:** Teachers may choose from the following bulleted options. The goal for students is to construct logically coherent explanations of phenomena that incorporate their current understanding of science or construct a model that represents it. Explanations or models should be consistent with the available evidence.

- Challenge 5 - Estimating the Speed of the Lunar Shadow:** Using data and information from the March 9, 2016 total solar eclipse, students will analyze data and use mathematical and computational thinking to determine the speed of the shadow between two towns. This information can be found at <https://eclipse2017.nasa.gov/challenge-5-%E2%80%93-estimating-speed-lunar-shadow>.
- How Far Away is the Moon?:** Mathematical and computational thinking are needed in this activity. Included is a script of a math lesson used to determine the distance of the moon from earth. Using the earth, sun, and moon alignment, students are led into a discussion of the conical (3D) view and the isosceles triangle view whose base coincides with the diameter of the earth. The umbral

and penumbral shadows are used in the storyline. Lunar eclipses are a part of this lesson as well. Students will be able to complete the exit ticket at the end of the lesson. This resource can be found at <https://www.engageny.org/file/114746/download/geometry-m2-topic-c-lesson-20-teacher.docx?token=c8N6jsCY>.

- Students will be able to obtain, evaluate, and communicate information by watching *A Rare, Spectacular Total Eclipse of the Sun* as a culminating activity. In this TED-Ed video geared towards school children, Andy Cohen explains how the tiny moon can eclipse the sight of the sun. Both the historical significance of solar eclipses and the process required to produce solar eclipses are explained. The video uses modeling and computational thinking to explain what happens during a total solar eclipse. There are questions at the end of the video for students to answer or to provide a basis for whole class or small-group discussion. <http://ed.ted.com/lessons/what-creates-a-total-solar-eclipse-andy-cohen>
- After modeling the alignment of the earth, sun and moon during a solar eclipse, have students model the same for a lunar eclipse.
- Have the students research and create models of what an eclipse would look like from the moon. This activity will involve mathematical and computational thinking about the rotation and orbital paths of the sun, moon, and earth.
- The students will interpret and analyze data to create an eclipse timeline. The timeline will incorporate data from eclipses during a time period assigned by the teacher (for instance, all total eclipses from 1700- 2100). The timeline can show details of the eclipses and interesting facts. Adding photos and art to the timeline would strengthen its value and interest.
- Students develop a kinesthetic model of a solar eclipse and ‘perform’ the model for other students. A sample rubric can be found at [www.readwritethink.org/files/resources/printouts/30700\\_rubric.pdf](http://www.readwritethink.org/files/resources/printouts/30700_rubric.pdf).
- Have students draw a labeled model of the geometry of the earth, sun, and moon required for a total solar eclipse for students in another state as a means of communicating information to those who can’t see the eclipse. The model labels should include sun, moon, earth, umbra, and penumbra. The areas where an annular eclipse and a partial eclipse would occur could also be included. An example of a rubric to evaluate this activity can be found at <https://www.rcampus.com/rubricshowc.cfm?sp=yes&code=M6384A&>.
- Have students write and illustrate a children’s book explaining the total solar eclipse to a fourth grade student.
- Students will read solar eclipse myths and legends. The following resources may be used:  
<http://www.kidseclipse.com/pages/a1b3c5d0.htm>  
<http://news.nationalgeographic.com/news/2013/11/131101-solar-eclipse-myth-legend-space-science/>  
<https://www.timeanddate.com/eclipse/solar-eclipse-myths.html>.

Following the reading, students will create a Venn diagram comparing the knowledge and beliefs that contributed to the myth about solar eclipses to what we know and believe today.

- After completing any modeling activity, students will create Chain Notes as a form of formative assessment. Students will be grouped based on teacher discretion. Students will be given the following question: What have you learned about solar eclipses? In each group, the paper is circulated from student to student in the group. Each student responds with one to two sentences related to the question and passes it to the next student in the group. Students can add a new thought or build on a previous thought. Each

student should have at least two opportunities to add to the “Note”. Each student in the group will then use the “Note” to create a paragraph answer to the question, working independently.

- After creating any modeling activity or eclipse informational session the students could create a comic strip based on the information they learned. A comic strip rubric can be found at this link:  
[http://www.readwritethink.org/files/resources/lesson\\_images/lesson195/comic-strip-rubric.pdf](http://www.readwritethink.org/files/resources/lesson_images/lesson195/comic-strip-rubric.pdf).
- Students will model and analyze data acquired during the eclipse unit to create role plays, TV or news reports. The students would be required to create a script and act out their ideas to other classes to help those teachers that do not teach science ensure that their students understand eclipses. Included is a script writing format that could be modified as a rubric to include data from the eclipse.  
[http://hargate.sandwell.sch.uk/curriculum/writing\\_website/literacy\\_genre\\_frames/Play%20script.pdf](http://hargate.sandwell.sch.uk/curriculum/writing_website/literacy_genre_frames/Play%20script.pdf)
- Students will generate a scientific question of their choice related to a total solar eclipse and obtain, evaluate, and communicate information to answer the question in a WebQuest. The Web Quest will be assigned to extend student knowledge beyond classroom instruction and will be based on student interest. A sample rubric for evaluating WebQuests can be found at  
<http://webquest.org/sdsu/webquestrubric.html>.
  - **The Introduction** to eclipses orients the WebQuest user and captures their interest.
  - **The Task** describes the activity's end product.
  - **The Process** explains strategies students should use to complete the task.
  - **The Resources** are the websites students will use to complete the task.
  - **The Evaluation** measures the results of the activity.
  - **The Conclusion** sums up the activity and encourages students to reflect on its process and results
- Students will obtain, evaluate, and communicate information about the eclipse through classroom instruction (modeling, analyzing and interpreting data) and then publish a newspaper about the eclipse. The students write articles for all the different sections of the newspaper. For example, have them write a letter to the editor in the voice of a particular character and their experiences with the eclipse. They could write a sports story and discuss how it was affected by the eclipse. They could write ads that publicize the eclipse and advice column on how to watch the eclipse. The newspaper must include data collected by students on a topic of their choice related to the eclipse.

### Extension Activities

These strategies and lessons will enable students to understand the total eclipse phenomena with more direct ties to specific subject area Performance Indicators. Teachers are encouraged and have the discretion to use any resources, regardless of subject, that may strengthen their students’ needs and understanding of the total solar eclipse. These are designed to enhance interest in, understanding of, and appreciation for this once in a lifetime event. **Performance Indicators** are listed below in purple. The text within the **Performance Indicators** highlighted in *orange* and *italicized/underlined* shows connections to SEPs.

*Note: Refer to the literary techniques shared in the previous section to facilitate learning with any literary/informational texts shared below.*

**Earth Science Performance Indicator:**

H.E.2B.3 *Use mathematical and computational thinking* to explain the motion of an orbiting object in the solar system.

**Exploration of Orbits**

**Essential Question: Why don't we see an eclipse every month?**

**Academic Vocabulary for this section:**

latitude	longitude	Solstice	spring equinox	transit
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**1. Possible introductory activities:**

*Choose from the following resources to support student engagement with the total solar eclipse and transaction with text.*

**Literary/Informational Texts:**

- Total Solar Eclipses: *Only for a Limited Time* is a Forbes article explaining the conditions needed for a total solar eclipse and why those conditions will not always exist.  
<https://www.forbes.com/sites/briankoberlein/2017/01/02/total-solar-eclipses-only-for-a-limited-time/#693e00081076>
- *NASA Satellites Ready When Stars and Planets Align*: Students will use mathematical and computational thinking while reading this post from NASA explaining the spring equinox, solstices, full moons, eclipses and transits. The goal of the post is to help students understand the basics of celestial alignments.  
<https://www.nasa.gov/feature/goddard/2017/nasa-satellites-ready-when-stars-and-planets-align>

**Videos**

- A video explaining the conditions needed for a total solar eclipse, based on the 1970 total solar eclipse is found at the link below.  
<http://www.space.com/11081-1970-solar-eclipse.html>

**2. Instructional Strategies:**

- Use a previously created solar eclipse model or create 3D models of the earth, moon, and sun to demonstrate solar and lunar eclipses. Illustrate why we do not see an eclipse every month. There are several activities and a video at link below.  
[https://nightsky.jpl.nasa.gov/download-view.cfm?Doc\\_ID=326](https://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=326)
- Use a modeling activity to demonstrate the alignment required of the Earth-Moon-Sun system in order to have solar and lunar eclipses. Instructions here use hula hoops so students can analyze and model how the moon moves through its phases each month and why an eclipse does not occur every new or full moon.  
[http://lasp.colorado.edu/home/wp-content/uploads/2012/05/A4\\_Modeling\\_Eclipses.pdf](http://lasp.colorado.edu/home/wp-content/uploads/2012/05/A4_Modeling_Eclipses.pdf)

- McGraw Hill Eclipse Interactive: Students can manipulate the computer model to alter distance, tilt, etc., using mathematical and computational thinking to understand the ratios needed for an eclipse to occur. This ties into other literatures that explain how solar eclipses were not possible in the distant past and will no longer be the way they are in the distant future due to the moon's changing distance from the earth.  
[http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::800::600::/sites/dl/free/007299181x/78778/Eclipses\\_Nav.swf::Eclipse%20Interactive](http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::800::600::/sites/dl/free/007299181x/78778/Eclipses_Nav.swf::Eclipse%20Interactive)
- Students use latitude/longitude data to plot some of the major cities that will witness the path of totality of the eclipse as it traverses the contiguous United States. Once students plot the points, they can connect the pathway and, using the scale of the map the teacher has chosen, draw the 70 mile umbra that would be projected onto the earth by the shadow of the moon.

City Name	Latitude	Longitude
Salem, OR	44.94 N	123.03 W
Huntington, OR	44.35 N	117.27 W
Clayton, ID	44.26 N	114.40 W
Idaho Falls, ID	43.49 N	112.03 W
Jackson Hole, WY	43.48 N	110.76 W
Casper, WY	42.87 N	106.31 W
Alliance, NE	42.09 N	102.87 W
Broken Bow, NE	41.40 N	99.64 W
Beatrice, NE	40.27 N	96.75 W
Oketo, KS	39.96 N	96.60 W
Kansas City, MO	39.10 N	94.58 W



Jefferson City, MO	38.57 N	92.17 W
Carbondale, IL	37.73 N	89.22 W
Shawnee National Forest, IL	37.55 N	88.40 W
Paducah, KY	37.08 N	88.60 W
Cerulean, KY	36.96 N	87.71 W
Nashville, TN	36.16 N	86.78 W
Nantahala National Forest, NC	35.23 N	83.57 W
Chattahoochee National Forest, GA	34.77 N	84.14 W
Anderson, SC	34.50 N	82.65 W
Columbia, SC	34.00 N	81.03 W
Charleston, SC	32.78 N	79.93 W

- Extension: Teachers may have students map specifically across South Carolina. They can find cities that the eclipse travels through at this website: [http://www.eclipse2017.org/2017/in\\_the\\_path.htm#SOUTH\\_CAROLINA](http://www.eclipse2017.org/2017/in_the_path.htm#SOUTH_CAROLINA).
- Map of the United States with latitude/longitude lines can be found online at Enchanted Learning. <http://www.enchantedlearning.com/usa/activity/latlong/map.GIF>
- An interactive map is found at [http://www.eclipse2017.org/xavier\\_redirect.htm](http://www.eclipse2017.org/xavier_redirect.htm) and could be used as reinforcement following this activity.

**Biology Performance Indicator:**

H.B.6A.1 *Analyze and interpret data* that depict changes in the abiotic and biotic components of the ecosystem over time or space (such as percent change, average change, correlation and proportionality) and propose hypotheses about possible relationships between the changes in the abiotic components and the biotic components of the environment.

**Exploration of Biotic and Abiotic Effects**

**Essential Question: How does a total solar eclipse affect the biosphere?**

**Academic Vocabulary for this section:**

abiotic	biotic	diurnal	nocturnal	photosynthesis
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**1. Possible introductory activities:**

*Choose from the following resources to support student engagement with the total solar eclipse and transaction with text.*

**Literary/Informational Texts**

- This is a news article written about a solar eclipse that occurred in the United Kingdom that discusses how animals could respond to the darkening of the day. Nocturnal animals may wake while diurnal animals might behave as if it is night (settling down to sleep or finding shelter). Students can hypothesize about what types of animals might have reactions and what those reactions may be. After the eclipse, they can share stories or find go-pro videos online of animal behaviors during the eclipse to see if their hypothesis was supported or unsupported.  
<http://www.telegraph.co.uk/news/earth/wildlife/11483137/Solar-eclipse-birds-to-stop-singing-as-Moon-passes-Sun.html&sa=D&ust=1489765588858000&usg=AFQjCNEfVicoCSnUoT842axG HN0gOUb8A>
- This is an additional article students may use as a resources for the above assignment: *How Cicadas, Squirrels, and Bees React to Solar Eclipses*  
<https://www.theatlantic.com/technology/archive/2014/10/how-cicadas-squirrels-and-bees-react-to-solar-eclipses/381842/>
- Information in this article provides evidence related to weather and temperature during a solar eclipse. The source is the *Daily Mail*, a newspaper in Great Britain. The article has graphs and charts. The information provides information for classroom discussion and predictions for the August 2017 event. Students should be able to explain why the most dramatic finding was the change in wind direction.  
<http://www.dailymail.co.uk/sciencetech/article-3749509/Solar-eclipses-change-weather-Falling-temperatures-alter-speed-direction-wind.html>

## 2. Instructional Strategies:

- *Solar Eclipse 2017 Life Responds* gets students involved on the actual day of the eclipse by having them participate in this Citizen Science Project which will produce data for a scientific research project.  
<https://www.calacademy.org/citizen-science/solar-eclipse-2017>
- Students perform several virtual labs on the importance of light in the process of photosynthesis and analyze and interpret the data collected. The information can be found at  
<http://www.northernhighlands.org/cms/lib5/NJ01000179/Centricity/Domain/38/photosynthesis-virtual-labs.pdf>. Following this activity, students write a hypothesis about how plants will respond to the change in light and temperature during a total solar eclipse.  
NOTE: The third link in the pdf is outdated for Virtual Lab #2. Replace with <http://www.kscience.co.uk/animations/photolab.htm>.
- *Where Birds Go at Night*: Read the article at <https://www.thespruce.com/where-birds-go-at-night-386443>. Based on the observational data in the article, students will select a bird and write about their predictions concerning the behavior of the bird during the total solar eclipse. Because of the amount of data and citizen science that will be part of this eclipse event, students could follow up with their own additional research to determine actual, observed behavior following the event in August.
- This is an article that discusses a study which reveals the meteorological impact of 2015 solar eclipse. <https://phys.org/news/2016-08-reveals-meteorological-impact-solar-eclipse.html>  
After reading the article, students research average mean temperature for their location and predict average temperature drop during the total solar eclipse after analyzing and interpreting the data they have read about and researched.

## Chemistry Performance Indicator:

H.C.2A.3 *Analyze and interpret* absorption and emission spectra to support explanations that electrons have discrete energy levels.

H.C.2B.3 *Obtain and communicate information* to compare and contrast nuclear fission and nuclear fusion and to explain why the ability to produce low energy nuclear reactions would be a scientific breakthrough.

H.C.4A.1 *Develop and use models* to explain the arrangement and movement of the particles in solids, liquids, gases, and plasma as well as the relative strengths of their intermolecular forces.

## Exploration of the Sun

**Essential Question: What can we learn about the corona during a total solar eclipse?**

## Academic Vocabulary for this section:

corona	coronal mass ejections	emission lines	magnetic field
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solar flares	solar wind	sunspots	wavelength
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### 1. Possible introductory activities:

*Choose from the following resources to support student engagement with the total solar eclipse and transaction with text.*

#### Literary/Informational Texts:

- This web site provides information about the solar corona from the University of Montana. There are short paragraphs on general characteristics, the magnetic field, the particles and solar wind, and the wavelengths emitted.  
<http://solar.physics.montana.edu/ypop/Spotlight/SunInfo/Corona.html>
- Solar Physics: The information on this website is from the Marshall Space Flight Center at NASA. The information is centered on the corona, and the hyperlinks provide additional information about the corona and its characteristics. The information can found at <https://solarscience.msfc.nasa.gov/corona.shtml>.
- *Spectra of the Solar Corona* : The website provides emission spectra for the solar corona during a solar eclipse. In analyzing and interpreting the data presented, students will be able to determine the major composition of the corona and how that information impacts the temperature of the corona. The information can be found at <http://prc.nao.ac.jp/extra/uos/en/no07/>.
- The Sun's Corona website has general information about the upper atmosphere of the sun's corona. The link to solar atmosphere provides pictures comparing coronas from two different eclipses. The information ca be found at <https://scied.ucar.edu/solar-corona>.
- *Space Weather: Sunspots, Solar Flares, and Coronal Mass Ejections* found at <http://www.space.com/11506-space-weather-sunspots-solar-flares-coronal-mass-ejections.html> provides additional information on some of the activity in the corona which may be seen during a total solar eclipse.

#### Videos:

- Watch the silent video *Beautiful Eclipse Seen in Australia Shows Sun's Corona* at <https://www.youtube.com/watch?v=Bf5SG-G8xeU>. Students will make observations during the video and share their observations as a part of a class discussion.
- *Scientists to Student: the Sun's Corona During Eclipse* can be found at <https://www.youtube.com/watch?v=vmdxCMy1XnI> . It describes the importance of studying the corona during a total solar eclipse.

### 2. Instructional Strategies:

- The students will obtain and communicate information through a Venn diagram, concerning the three different types of nuclear reactions: fusion, fission, and radioactive decay. They will then examine how the sun's energy is produced during nuclear fusion and relate this to humans' inability to look at the sun directly.  
[http://streaming.discoveryeducation.com/teacherCenter/lessonPlans/pdfs/9-12\\_Science\\_NuclearFusionThePowerOfTheSun.pdf](http://streaming.discoveryeducation.com/teacherCenter/lessonPlans/pdfs/9-12_Science_NuclearFusionThePowerOfTheSun.pdf)
- *The Flash Spectrum of the Sun*: Students will use the Sky Image Processor to analyze and interpret a flash spectrum taken at the

total solar eclipse of March 7, 1970 in North Carolina.

<http://www.phys.vt.edu/~heremans/Astrolab1156/Readings/flash.html>

- The students analyze and interpret an emission spectrum image of the solar spectrum. The students will determine which elements are represented by the emission spectrum. This lesson includes all the information needed to inform the students of electromagnetic radiation.

[https://sunearthday.nasa.gov/2006/materials/spectrabook\\_ver2.pdf](https://sunearthday.nasa.gov/2006/materials/spectrabook_ver2.pdf)

#### Physics Performance Indicator:

H.P.2D.3 *Obtain information* to communicate how long-term gravitational interactions govern the evolution and maintenance of large-scale structures in the universe (such as the solar system and galaxies) and the patterns of motion within them.

#### Exploration of Orbits

**Essential Question: How can Kepler's Laws be used in modeling a total solar eclipse?**

#### Academic Vocabulary for this section:

declination	Kepler's laws	orbital period	orbital radii	parallax	transits
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#### 1. Possible introductory activities:

*Choose from the following resources to support student engagement with the total solar eclipse and transaction with text.*

#### Literary/Informational Texts:

- *Why aren't there eclipses every month?:* This source explains why we don't see an eclipse every month. Understanding the information leads to a discussion about Kepler's Laws and why eclipses are not monthly. <https://phys.org/news/2015-11-eclipses-month.html> .
- This website's information is an overview for science teachers about Kepler's Three Laws of Planetary Motion. It provides examples, applications, problems, related history, and resources for classroom materials. <https://www-spf.gsfc.nasa.gov/stargaze/Kep3laws.htm>
- This website has general information about Kepler's three laws. The Law of Periods can be used to calculate period of moons. <http://hyperphysics.phy-astr.gsu.edu/hbase/kepler.html> .
- This PowerPoint that contains information on Kepler's laws and explains the difference between annular and solar eclipses.

[http://astro.physics.uiowa.edu/~srs/2952\\_10/Lec10.ppt](http://astro.physics.uiowa.edu/~srs/2952_10/Lec10.ppt)

- This website contains information to help with Kepler's laws and planetary transits.  
<https://kepler.nasa.gov/Science/about/characteristicsOfTransits/index.cfm>

#### Videos:

- The lecture from Khan Academy explains the scale of the earth and sun. The video is 9:30 minutes.  
<https://www.khanacademy.org/science/cosmology-and-astronomy/universe-scale-topic/scale-earth-galaxy-tutorial/v/scale-of-earth-and-sun>

## 2. Instructional Strategies:

- *The Last Total Solar Eclipse.....Ever!:* This is an activity centered around the angular size of the moon and the sun. Because the moon is steadily pulling away from earth, there will be a time when these two angular sizes no longer match up. Students will use mathematical and computational thinking to determine when that will happen. Students will use that information to prepare an infographic to explain the angular relationship to other students.  
<http://spacemath.gsfc.nasa.gov/earth/4Page28.pdf>.  
A rubric can be found at <http://den.library.jwu.edu/c.php?g=228568&p=1540205>.
- Astronomy Education at the University of Nebraska: Lincoln has designed a Planetary Orbits Lab designed to facilitate understanding of Kepler's Three Laws of Motion as well as how velocity and force relate to the orbits. Students will use mathematical and computational thinking to complete the activity. All information, including download of the Planetary Orbit Simulator, are all the introductory page. Students will communicate what they have learned by completing the Student Guide pdf accompanying the simulator. The resource can be found at <http://astro.unl.edu/naap/pos/pos.html>. An Eccentricity Demonstrator can be found at [http://astro.unl.edu/naap/pos/pos\\_background1.html](http://astro.unl.edu/naap/pos/pos_background1.html).
- *Students Measure the Lunar Distance* is a website that provides an introduction to the 2-D mathematics used to explain solar eclipses. Additional links for explanation are located on the website. Students who have studied basic trigonometry will be able to understand the information presented. Once the students understand the mathematics, they can complete the observation sheet on the day of the actual eclipse and send it back to the teacher to be used in classes the next year to estimate the distance of the moon and its diameter using the student data. NOTE: The information in the activity is based on the August 1999 eclipse. A teacher could work through this example and then have students do the same with August 21, 2017 eclipse. The information needed can be found in links on the website. <http://www.eso.org/public//outreach/eduoff/aol/market/collaboration/eclipse99/projects/solecl-2d.htm>.
- The students analyze information in *Transit Tracks*. The intent of the investigation is to describe a transit and the conditions needed for one to occur, to describe how the size and distance a planet is from its star affects transit behavior, and to interpret graphs of brightness vs time to deduce information about planet-star systems. Simple materials are required. There are optional activities using sensors for those teachers who many want to extend learning. Teacher resources on the website include a video and

a PowerPoint. The information can be found at <https://kepler.nasa.gov/education/activities/transitTracks/>. Information explaining the Kepler Mission can be found at [https://kepler.nasa.gov/files/mws/Candidates\\_poster\\_back\\_28Dec11\\_print.pdf](https://kepler.nasa.gov/files/mws/Candidates_poster_back_28Dec11_print.pdf).

- Students can use their knowledge of Kepler's Laws to complete the following activities. Student learning will be communicated, along with their arguments for their choices.
  - [http://astro.unl.edu/interactives/kepler/paper/Kepler\\_1.pdf](http://astro.unl.edu/interactives/kepler/paper/Kepler_1.pdf)
  - [http://astro.unl.edu/interactives/kepler/paper/Kepler\\_2.pdf](http://astro.unl.edu/interactives/kepler/paper/Kepler_2.pdf)
  - [http://astro.unl.edu/interactives/kepler/paper/Kepler\\_3.pdf](http://astro.unl.edu/interactives/kepler/paper/Kepler_3.pdf)
  - [http://astro.unl.edu/interactives/kepler/paper/Kepler\\_4.pdf](http://astro.unl.edu/interactives/kepler/paper/Kepler_4.pdf)
  - [http://astro.unl.edu/interactives/kepler/paper/Kepler\\_5.pdf](http://astro.unl.edu/interactives/kepler/paper/Kepler_5.pdf)
- Students use mathematical and computational thinking to create models by using a series of thirty-one images of Jupiter's four Galilean moons to find their orbital periods and orbit radii and test various mathematical expressions to find a "constant" relationship between orbit period (T) and orbit radius (R) to arrive at Kepler's 3rd Law. This resource can be found at <https://kepler.nasa.gov/files/mws/OrbitsOfJupitersMoons.pdf>.

### \*Science and Engineering Practices

Support for the guidance, overviews of grade level progressions, and explicit details of each SEP can found in the Science and Engineering Support Doc ([http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete\\_2014SEPsGuide\\_SupportDoc2\\_0.pdf](http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf)). It is important that teachers realize that the nine science and engineering practices are not intended to be used in isolation. Even if a performance indicator for a given standard only lists one of the practices as a performance expectation, scientists and engineers do not use these practices in isolation, but rather as part of an overall sequence of practice. When educators design the learning for their students, it is important that they see how a given performance expectation fits into the broader context of the other science and engineering practices. This will allow teachers to provide comprehensive, authentic learning experiences through which students will develop and demonstrate a deep understanding of scientific concepts.

The SEPs are listed within the different applications of learning in this document, but can also be accessed by clicking on the SEP support document link above.

### \*Cross Cutting Concepts (<http://www.nap.edu/read/13165/chapter/8>)

The link above provides support from the Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012). The text in **blue** and ***italicized/underlined*** below provides a brief explanation of how the specific content ties to the CCC's. The concepts have applications across all domains of science. Therefore, they can be considered as a way of linking together all science domains.

1. **Patterns:** The National Research Council (2012) states that "observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them" (p. 84). [\*The earth and moon move in predictable patterns in relationship to the sun and each other. These patterns of motion sometimes result in shadows known as an eclipse. Light moves in a predictable pattern. If an object does not allow light to pass through it, the light is blocked producing a shadow.\*](#)
2. **Cause and effect -Mechanism and explanation:** The National Research Council (2012) states that "events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts" (p. 84). [\*A solar\*](#)



*eclipse is the result of a causal relationship between the earth, sun, and moon. The moon moves between the earth and sun, resulting in light from the sun being blocked from the earth, resulting in a shadow on the earth's surface. This is known as solar eclipse.*

3. **Scale, proportion, and quantity:** The National Research Council (2012) states that “in considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance” (p. 84). *During an eclipse, the light from the sun (a much larger object) can be blocked by the moon (a smaller object) due to the greater distance the sun is from the earth.*

4. **Systems and system models:** The National Research Council (2012) states that, “defining the system under study-specifying its boundaries and making explicit a model of that system-provides tools for understanding and testing ideas that are applicable throughout science and engineering” (p.84). *Models can be used to show how motions in the Sun-Earth-Moon system cause earth phenomena such as a solar eclipse.*

*\*Teachers have the discretion to enhance the selected SEP’s and CCC’s.*

#### **Additional Resources:**

**Should teachers wish to provide students with additional experiences related to the total solar eclipse, the following resources are recommended.**

- An Observer's guide to the viewing the eclipse from *The Science Teacher Magazine March 2017*: This guide covers all the information needed for teaching the eclipse. Download the information at [static.nsta.org/extras/solarscience/SolarScienceInsert.pdf](http://static.nsta.org/extras/solarscience/SolarScienceInsert.pdf) .
- This website is from the Astronomical Society of the Pacific. It contains articles, lessons, and activities concerning eclipses.  
<http://www.astrosociety.org/education/astronomy-resource-guides/eclipse-resource-guide/>
- The Challenger Center has put together all the information a teacher could need to teach eclipses along with models, viewers, and articles.  
[http://thechallengercenter.net/?page\\_id=1768](http://thechallengercenter.net/?page_id=1768)
- Teacher’s Resource book by Andrew Fraknoi and Dennis Schatz contains activities that help teachers prepare their students for the eclipse.  
[http://www.nsta.org/store/product\\_detail.aspx?id=10.2505/9781941316078](http://www.nsta.org/store/product_detail.aspx?id=10.2505/9781941316078)
- This is a great website explains eclipses with explanatory animations and many different methods.  
<http://www.eclipse2017.org/>  
Become part of the eclipse mega movie. Use a personal camera to video the total eclipse and send in to the Mega Movie project. All instructions are included with the website.  
<https://knowridge.com/2017/02/megamovie-project-to-crowdsource-images-of-august-solar-eclipse/>.
- NASA’s “Dancing along the path”: During the total solar eclipse, capture a short video of yourself and your students doing an original dance inspired by the eclipse. Keep it to less than one minute. Avoid any kind of copyrighted music or materials in the background that could prevent your video from being posted. Submit your video to the **Flickr site** (<https://www.flickr.com/groups/nasa-eclipse2017/>) using the keyword "**Dancing Along the Path**" with your name, viewing location, and additional comments so classes can receive full credit.  
<https://eclipse2017.nasa.gov/dancing-along-path>
- NASA’s “The Time Capsule”: There will be another total solar eclipse in the U.S. in 2024. Have students imagine what their lives and the world may be like in 2024. What advice could they share with students watching the eclipse in 2024? Students then could either write a letter to themselves to be opened in 2024 or create a time capsule for home or school.

<https://eclipse2017.nasa.gov/time-capsule>

- NASA's "The eclipse in six": This is an activity that asks students to write six words that encompass the feeling they had as they watched the total eclipse. The students will upload their six words to a google form that will incorporate their thoughts in a NASA time capsule to be opened in 2024 when the next full eclipse will occur.

<https://eclipse2017.nasa.gov/eclipse-six>

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